BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

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Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. VI LANCASTER, PA., DECEMBER, 1915 No. 4

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EDITORIAL.

The 1916 Meeting.—By a vote of the Council it has been decided to hold the 1916 meeting at the University of Virginia. Upon notifying that Institution of the fact that the Society had accepted their invitation we received the following letter from President Alderman:

"TO THE MEMBERS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

"*Gentlemen:* The opportunity afforded this University of rendering service to the institutions of the South, particularly through the medium of your Convention, is especially gratifying to me.

"In many ways engineering education in the past has left much to be desired in respect to maximum efficiency, and the concerted action of the Society for the Promotion of Engineering Education cannot but ultimately result in the formation and formulation of a substantial groundwork upon which may be erected a structure capable of furnishing training to the future engineers along the lines which will make them of the highest service both as engineers and as broad-minded citizens. We may well be proud of a part in this much-needed work of correlation and up-building.

"It seems particularly appropriate that efforts to mould ways and means for a proper and adequate engineering training should be made now in the South, where engineering enterprises are springing up so rapidly, since the whole work of engineering training here is largely in the formative stage and thus is most readily amenable to a plan resulting from the joint efforts of leaders in engineering education in this country.

"Progress will be necessarily slow in some respects: conservatism frowns upon radical changes, yet there must be continuous progress and it should be directed along the sanest lines, guided by the experience and wisdom of the best minds in the profession.

"Engineering is now so interwoven with the activities of mankind, touching it at every point and in such broad ways, that only the clearest and best prepared minds are capable of leadership to greater attainments.

"The broadened interpretation now accorded to the term 'engineer' necessitates a correspondingly widened outlook upon large problems in the student days. No longer is the

engineer simply confined to the technical details of his profession but he is a leader of men, and in a larger sense he should be a leader in the civic, political and economic life of his times.

"The fields of endeavor for the properly trained engineer are multiplying with amazing rapidity and the older methods of training are no longer adequate to cope with the new demands.

"How shall the required results be obtained? How get broader-mindedness, how make the work more intensive, and yet conserve the health and time of the student so that he may enter upon his life work with adequate preparation and with initiative, spirit, courage and strength? These are all questions for your Society to study, debate and answer to the best of your ability.

"The Society for the Promotion of Engineering Education, like most organizations of similar character, has required some time to find itself and to commence to realize some of its ideals, and it is the greater honor to us that your immediate efforts for broad advances are to be launched this year through the University of Virginia.

"I take very great pleasure in extending a most hearty and cordial invitation to you to visit the University of Virginia for your annual convention next June, to help us and the South in solving the problems which we all have in common in connection with engineering education. With pleasureable anticipations of meeting and greeting many of you here, I am,

"Faithfully yours,

EDWIN W. ALDERMAN,
President, University of Virginia.

NOVEMBER TWENTY-FOURTH.

THE MONTHLY LETTER.

A meeting of the Executive Committee was held in New York City in the rooms of the American Institute of Electrical Engineers, November 13. At this meeting a number of mat-

ters which are of general interest to the Society were discussed. Among these are the following:

Hereafter the Society will charge $2.00 to subscribers of the BULLETIN who are not members of the Society. Previous to this only $1.00 has been charged libraries and a few individual subscribers and as this is less than the cost of publication the Committee believes it wise to increase the charge.

The question of publishing in the *Proceedings* important papers which appear in the BULLETIN was thoroughly discussed and it was decided to recommend to the Publication Committee the continuation of the present practice of publishing in the *Proceedings* only those papers and reports which are presented at the annual meeting.

The Committee decided to recommend changes in the Constitution and By-laws of the Society whereby the fiscal year of the Society is to end June 30 and all bills for dues hereafter to be marked "payable in advance July 1." The *Proceedings* will not be mailed to those who owe the Society $8.00 or more at the time of publication. No BULLETINS are to be sent to those members who owe $8.00 or more on October 1. These proposed changes will be submitted to the 1916 meeting.

It was decided that the names of the sponsors should be included on the lists of applicants sent to Council and printed in the BULLETIN.

It was decided to recommend to the Publication Committee that the reports of the committees should be published in the BULLETIN in the order in which they are received and that the order of the program at the annual meeting should conform to this order in so far as possible.

In order to avoid undue complication it was decided that wherever possible questionnaires pertaining to the work of the committees should be sent out from the Secretary's office.

In the past a number of teachers have been listed in the annual yearbook as teachers and consulting engineers. It was decided to omit the word consulting engineer where the member is listed as a teacher.

SOCIETY NOTES.

The Meeting of Urban Universities at the University of Cincinnati.—The meeting of the Association of Urban Universities was exceptional in that it brought together university men, business men and civic workers. As this was the second meeting of the Association and as there were only sixteen charter members many of the delegates came to learn rather than to discuss. The subject of the Conference was "Coöperation Between the Cities and the Universities in Training for Public Service." The addresses were in practically all cases of broad general interest and appeal. The meeting was attended by perhaps seventy delegates representing widely divergent types of universities and of national societies. These points in the address seemed to stand out with great clearness.

1. That there is a great field and need for public service on the part of universities located in cities.

In regard to the first point there was a remarkable unanimity of opinion as to the desirability of coöperation. The matter was discussed from the standpoint of the city, the university and the business man. It was assumed that where the university failed, it was due to the hard-shelled nature of some of the pedagogues rather than the lack of proper opportunity for coöperation.

2. That the methods of coöperation with municipalities are of almost endless variety.

Many of the speakers pointed out the almost infinite variety of ways in which the university can help the city. Of great interest was the information presented by the University of Cincinnati in regard to the Municipal Research Bureau and kindred activities in Cincinnati.

3. That coöperation proves of great value to the universities themselves.

The opinion was voiced from the floor as well as the platform that coöperation had enlivened and revivified much of the work of students especially in the line of economics and sociology.

4. That there is great need in the faculties of our municipal universities for the clear headed, red-blooded men of initiative and enthusiasm.

Almost every speaker alluded to the crying need for *real men* to do the work of coöperation. The feeling that the old-line professor, cloistered as he has been, was almost useless in this work.

5. That courses should be given training a limited number of men for official public service.

The thought was strongly presented that the success or failure of the whole scheme depended upon the personality and training of the men who were to officially enter the public service, within the next few years. For that reason especial care should be taken in choosing the men for training.

6. That all students should study civic problems to the end that a sense of interest and civic patriotism be aroused.

It was the general feeling that more courses dealing with civic problems should be given as a matter of general education.

7. That coöperation with civic improvement associations, chambers of commerce, etc., should be strongly encouraged.

It was strongly urged that chambers of commerce, civic federations, etc., offer their services in connection with the university, to the benefit of both bodies as well as the municipality.

8. That many urban universities are in very close touch with the problems of their municipalities and are actually cooperating with the city governments in a definite and helpful way.

The addresses showed quite clearly the progress of work done and that a great deal of work had been done toward the actual and definite coöperation with cities.

A. R. CULLIMORE,

DEAN, COLLEGE OF INDUSTRIAL SCIENCE, TOLEDO UNIVERSITY.

PERSONALS.

Prof. Vladimir Karapetoff of the Electrical Engineering Department of Cornell University, has been invited by the Pan-American Union to read a paper concerning "What is Engineering Education Contributing Toward Scientific Progress and Invention," before the second Pan-American Scientific Congress, which will meet in Washington, D. C., from December 17, 1915, to January 8, 1916. Professor Karapetoff will leave a few days after Christmas to attend this congress.

APPLICANTS FOR MEMBERSHIP.

ANDERSON, R. J., Instructor in Metallurgy, University of Missouri, Rolla, Mo. L. E. Garrett, A. L. McRae.

BAILEY, A. R., Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor. M. E. Cooley, H. E. Riggs.

BEGGS, G. E., Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. F. H. Constant, H. S. S. Smith.

BLISS, C. P., Professor of Mechanical Engineering, University of New York, New York, N. Y. Alex. Haring, C. E. Houghton.

BROWNE, E. T., Instructor in Mathematics, University of Virginia, University, Va. E. J. Oglesby, J. S. Lapham.

CANNON, J. H., Associate Professor of Electrical Engineering, A. & M. College of Texas, College Station, Tex. H. E. Dyche, L. H. Harris.

CARPENTER, D. E., Manager of Education, International Textbook Co., Scranton, Pa. F. L. Bishop, L. H. Harris.

CHEDSEY, W. R., Assistant Professor of Mining, Colorado School of Mines, Golden, Colo. Harry Wolf, R. S. Hawley.

COOPER, F. E., Member, Development Staff, Bird & Son, East Walpole, Mass. A. S. Jewett, F. B. Gilbreth.

DUCEY, E. J., Instructor in Civil Engineering, Pennsylvania State College, State College, Pa. E. L. Waterman, E. D. Walker.

FULLAN, M. T., Professor of Machine Design and Drawing, Alabama Polytechnic Institute, Auburn, Ala. J. J. Wilmore, G. N. Mitchie.

GRAY, ALEXANDER, Professor in Charge of Electrical Engineering, Cornell University, Ithaca, N. Y. V. Karapetoff, A. C. Stevens.

HANNA, U. S., Associate Professor of Mathematics, Indiana University, Bloomington, Ind. H. E. Dyche, F. L. Bishop.

HITCHCOCK, W. A., Assistant in Engineering Mathematics, University of Colorado, Boulder, Colo. W. C. Huntington, I. C. Crawford.

JORDAN, H. H., Associate in General Engineering Drawing, University of Illinois, Urbana, Ill. H. W. Miller, R. E. Davis.

KOERBER, G. A., Professor of Electrical Engineering, Delaware College, Newark, Del. W. S. Sypherd, G. S. Harter.

LAMPHRIES, V. D., Superintendent of Engineering Shops, Robert College, Constantinople, Turkey. J. R. Allen, L. A. Scipio.

LANGILLE, H. B., Assistant Professor of Machine Design and Mechanical Drawing, University of California, Berkeley, Cal. C. L. Cory, J. N. LeConte.

MALLORY, W. F., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. M. S. Ketchum, H. E. Phelps.

MCCANDLISS, E. S., Assistant Professor of Civil Engineering, Missouri School of Mines, Rolla, Mo. L. C. McCandliss, L. H. Harris.

MOYLE, M. W., Assistant in Mechanical Engineering, University of Colorado, Boulder, Colo. M. S. Ketchum, W. C. Huntingdon.

MUNRO, G. W., Assistant Professor of Mechanical Engineering, Purdue University, LaFayette, Ind. C. B. Veal, G. H. Young.

PEHRSON, E. W., Assistant Professor of Mathematics, University of Utah, Salt Lake City, Utah. H. E. Dyche, F. L. Bishop.

PENN, J. C., Assistant Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill. H. M. Raymond, C. E. Paul.

RIDOUT, JOHN, Student Assistant in Mathematics, University of Virginia, University, Va. E. J. Oglesby, J. S. Lapham.

SEARSON, J. W., Professor of the English Language, Kansas State Agricultural College, Manhattan, Kans. A. A. Potter, L. E. Conrad.

SHATTUCK, L. H., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. C. S. Sperry, M. S. Ketchum.

STANLEY, W. E., Assistant in Hydraulic Laboratory, Purdue University, LaFayette, Ind. F. W. Greve, Jr., W. K. Hatt.

TUCKER, E. N., Instructor in Mathematics, University of Virginia, University, Va. E. J. Oglesby, W. S. Rodman.

COLORADO SCHOOL OF MINES, Golden, Colo., Wm. B. Phillips, President.

UNIVERSITY OF COLORADO, Boulder, Colo., Livingston Farrand, President.

LAFAYETTE COLLEGE, Easton, Pa., J. H. MacCracken, President.

TOLEDO UNIVERSITY, Toledo, O., A. M. Stone, President.

BOOKS RECEIVED.

Machine Elements and Power Transmission. By L. C. STARKEY. Published by the Author. 1915.

The Principles of Dynamo Electric Machinery. By B. F. BAILEY. Published by McGraw-Hill Book Co. 1915. Price $3.00 net.

BOOK REVIEWS.

Properties of Steam and Ammonia. By G. A. Goodenough, Professor of Mathematics, University of Illinois. John Wiley & Sons, Inc., New York, 1915. Pp. 108. Price $1.25 net.

This book includes ten complete tables on the properties of the vapors together with logarithmic and conversion tables.

Professor Goodenough has formulated in a thermodynamically consistent manner the results of careful study and investigation of the most trustworthy and recent experimental data available.

The properties of steam and ammonia are tabulated for a wide range of conditions which will meet all practical requirements. A special table on mixtures of air and saturated water vapor will prove of particular value in the solution of problems which involve hygrometric conditions. Mollier diagrams for both steam and ammonia are also included with examples illustrating their use.

J. W.

COLLEGE NOTES.

The Polytechnic Institute of Brooklyn.—President Atkinson of the Brooklyn Polytechnic Institute has just issued an annual report that is interesting for its statement of the growth of the college during the last ten years in both its day and evening departments. The increase in registration from 1904–1905 to 1915–1916 is significant, for in 1904–1905 the day registration was 95 and the evening 140, while at the beginning of the present college year the day registration was 215 and the evening attendance 560, a gain in total attendance of over 300 per cent. A large percentage of these students received their preparation in the high schools of New York City, enabling them to meet the high entrance requirements of the Polytechnic.

Chemical Engineering, we learn from the report, has this year claimed twenty-five per cent. of the entering students, a fact that is noteworthy since this is a five-year course. The

publicity given our national need for chemical products is advanced as a possible cause for this increase.

One of the most instructive of the departmental reports summarized by President Atkinson is that of Dr. Sheldon, head of the Electrical Engineering Department. From this we learn that practically two thirds of the students of the Institute make serious efforts to earn something to assist them in paying their college expenses. A total amount of $19,978, or an average of $212 per worker, has been earned during the year by 94 students. These men followed an interesting list of pursuits, among which were ironing shirts, working on ladies' garments, acting as post-office clerk, chauffeur, toy-maker, fireman, farmer, barber, wheelwright, motor-boat operator, distributors of pamphlets, and general salesmen in stores.

The growth of the college in point of tuition fees is also commendable, increasing as it did year by year from $19,-156.37 in 1905 to $71,000 (estimated) in 1916. The number of graduates has increased from 25 in 1905 to 56 in 1915.

President Atkinson also emphasized the fact that the college had through its increased attendance, day and evening, outlived its present quarters, as is evidenced by the necessity of converting the halls into chemical laboratories, the chapel into a machine shop, the individual class assembly rooms into drafting rooms and administrative offices, while the library has had to be used as a meeting place for the various engineering, literary, and social clubs of the college.

Thus, although the Institute is fulfilling every demand made upon it, as a high-grade technical college, its further usefulness and its sustained efficiency are dependent upon additional buildings for laboratories and lecture rooms, upon enhanced equipment, and a larger teaching force.

University of Illinois.—New appointments to the staff of the College of Engineering are:

Albert Victor Blininger as Professor and Head of the Department of Ceramic Engineering; William Mathews Hekking as Associate in Free-hand Drawing in the Department of

Architecture; Carl Victor Burger as Instructor in Drawing in the Department of Architecture; Lemuel Cross Dillenback as Instructor in Architectural Design; C. Stanley Sale as Assistant to the Director of the Engineering Experiment Station and Instructor in Civil Engineering; Charles Steuer Fazel as Part-time Assistant in Physics. Appointments also include nine research fellows.

At the commencement of the University on June 16, 1915, 195 baccalaureate degrees were granted to the students of the College of Engineering; also 22 master's degrees, 8 professional degrees, and 2 doctor's degrees were conferred by the College.

The number of students registered in the College of Engineering ten days after the beginning of the new year is as follows:

Architecture, 161; Architectural Engineering, 167; Ceramic Engineering, 65; Civil Engineering, 189; Electrical Engineering, 259; Mechanical Engineering, 238; Mining Engineering, 30; Municipal and Sanitary Engineering, 31; Railway Engineering, 44; total, 1,184.

The Department of Ceramics was transferred from the College of Liberal Arts and Sciences to the College of Engineering on July 1, 1915. The first course in ceramics was given in 1905 but during the past ten years development has been very rapid due to the active support of the clay-working interests of the State and the effective coöperation of the department with these interests in solving the large problems that confronted them. The new building is a handsome structure, combining to a large degree the products of the clay workers' art. The cost will approximate $150,000.

On Oct. 21, 1915, the staff of the Engineering College presented to Professor C. R. Richards an elegant smoking set as a testimonial of appreciation of his work as Acting Dean during the preceding two years.

Dean W. F. M. Goss has again assumed the deanship after an absence of two years while serving as Chief Engineer of

the Committee on Electrification and Smoke Prevention of the Chicago Chamber of Commerce.

The annual inspection trip of the senior students of the College of Engineering will occur on November 22 to 24 inclusive. The trip includes Chicago and surrounding towns of Gary, Whiting and others. The shop trip is now a requirement in all engineering courses and the one this year is the first in which the seniors of the entire college participate. Consequently it will be a more extensive affair than in any previous year.

Massachusetts Institute of Technology.—President Richard C. Maclaurin announces that the date for the dedication of the New Technology has been fixed by the Executive Committee of the corporation for Wednesday, June 14, 1916.

The time selected is a fortunate one when the various forces of the Institute will be massed in Boston. Class day with its student festivities has been regularly set for Monday, June 12, and the graduation exercises will follow on Tuesday. These important occasions will ensure the presence of the eighteen hundred students of the Institute, who will form an impressive background at the ceremonies. The time is that of the annual meeting of the great federation of Technology Clubs, which will convene in Boston and also of the M. I. T. Alumni Association, the parent organization whose home is here. There will be an unprecedented gathering of these men interested to see the progress of their Alma Mater since their own student days and for the central feature in the celebration there will be the host of representatives of other educational institutions in the land, and in other lands in fact, come to do honor to Boston's famous school.

Michigan Agricultural College.—Professor Victor T. Wilson, until recently a member of this Society, has resigned his position as head of the Department of Drawing and Design at the Michigan Agricultural College at East Lansing, Mich., to take effect at the end of this college year. Professor Wilson was instructor in drawing in Cornell University from 1893 to 1903,

and in charge of General Engineering Drawing for three years at the University of Illinois. He has been at M. A. C. for the past seven years. He is the author of four well-known textbooks on drawing.

University of Minnesota.—Dr. G. D. Shepardson attended the annual meeting of the National Electric Light Association Committee on Relations with Educational Institutions. The meeting was held in New York City on November 11. Dr. Shepardson is chairman of the subcommittee on employment. During the past year the committee has been working on the problem of getting summer employment for engineering students in electric central stations and found places last summer for 262 students. The N. E. L. A. is an organization representing the electric central stations of the United States. They represent a gross income of over $500,000,000 annually and employ over 100,000 people. Last summer's work is just a small beginning of a movement that is intended to get a much larger percentage of technical men started in the central station field.

University of Pennsylvania.—Professor R. H. Fernald attended the inauguration of Dr. J. H. MacCracken as president of Lafayette College, October 20. H. E. Ehlers, Professor of Experimental Engineering, has returned to the University after a leave of absence during which time he was Assistant Engineer with the Public Service Commission of Pennsylvania. Dr. H. M. Trublood has been advanced from the grade of instructor to Assistant Professor of Electrical Engineering.

New instructors have been appointed for the year 1915–16 as follows: *Civil Engineering*—William S. Lohr, George G. Mankey, Joseph A. Russell; *Electrical Engineering*—Willett C. DuVal, C. Washington Plass, Frank Short, W. W. Crawford; *Mechanical Engineering*—Harold N. Comins, Roy S. Farr, Chauncey H. Swett, William F. Turnbull.

The total number of students registered in the Towne Scientific School up to November 1 was 865. Of this number 158

are civil engineers, 121 are chemical engineers, 155 are electrical engineers, and 139 are mechanical engineers.

Yale University.—Professor A. J. DuBois, Head of the Department of Civil Engineering in the Sheffield Scientific School, died October 19. Professor J. C. Tracy has been appointed to fill the vacancy.

Professor Tracy was graduated from the Sheffield Scientific School in 1890, and received the degree of Civil Engineer in 1892. During the year 1891–2 and in subsequent summers he was engaged in bridge construction work. He was made an assistant in 1892, an instructor in 1894, assistant professor of structural engineering in 1902, professor of structural engineering in 1915, and now becomes professor of civil engineering, for which position he is peculiarly well qualified. During this period of twenty-three years at Yale, Professor Tracy has devoted much time and thought to the study not only of the needs of his own department, but of the problems which have confronted other leading universities as well. He has also been active in the Yale Engineering Association, which was recently formed to promote the coöperation of the alumni in the development of the engineering courses at Yale.

Professor Tracy is the author of an "Introductory Course in Mechanical Drawing" (1898), "Plane Surveying" (1907), "Exercises in Surveying for Field and Office Work" (1909), and "Descriptive Geometry" (1914). His systematic thoroughness is reflected in his writings, especially in his "Plane Surveying" which has met with unusual success.

W. E. DICKINSON.

Professor William Elmore Dickinson, born October 4, 1875, at Williamsburg, Va. Died November 4, 1915, at El Paso Sanitorium, El Paso, Texas. In 1894 received the L.I. degree from Virginia State Normal School; A.B. William and Mary College, 1900, M.E.(E.E.) Cornell University, 1904; M.M.E., ibid., 1909.

Professor Dickinson taught six years in the public schools of Virginia before entering Cornell University and prior to becoming a member of the engineering faculty of the West Virginia University was one of the staff on Electric Railway Tests of the Louisiana Purchase Exhibition; student apprentice Stanley Electric Mfg. Co., Pittsfield, Mass., and a member of the engineering staff of the Westinghouse, Church, Kerr and Co., New York, N. Y.

He entered the West Virginia University as instructor in Electrical Engineering in the fall of 1905; was made Assistant Professor of Electrical Engineering, 1906; Associate Professor, 1907, and Professor of Electrical Engineering, 1909. In 1911 the Department of Electrical Engineering was made a separate degree, giving unit of the College of Engineering with Professor Dickinson at its head, which position he held at the time of his death.

Professor Dickinson was not only an expert in his subject but was also an able teacher and an energetic worker. During the past year he was instrumental in organizing the West Virginia Student Branch of the American Institute of Electrical Engineers. He was a member of the American Institute of Electrical Engineers; The Society for the Promotion of Engineering Education; and the Phi Beta Kappa Fraternity (William and Mary, West Virginia University).

Professor Dickinson is survived by his wife, Mrs. Emma Read Dickinson, whom he married near Harborton, Va., in 1905.

SHOP INSTRUCTION AT UNIVERSITY OF ILLINOIS.

BY B. W. BENEDICT,

Director Shop Laboratories, University of Illinois.

The policy of the University of Illinois in regard to administration of the courses in shop work for engineering students was announced to the Society by Dean W. F. M. Goss in his paper "The Administration of College shop Laboratories" before the Boston convention in 1912. In this paper the author pays a strong tribute to the work done in college shops but warns that changing conditions in industry and engineering demand the consideration of educators if this feature of technical education continues on the same plane of usefulness it has in the past. There is no mistaking his meaning when he says: "From these considerations it should be apparent that the ideals which hitherto have stimulated the work of the shop laboratories are sustained by arguments which are losing force as time proceeds. So true is this that the question is already fairly before the technical schools as to whether the existing shop courses which have served so long and so well shall be entirely abandoned. If not abandoned they must be placed upon a new plane of excellence."

Mindful of the undoubted influence of the shop laboratory upon the development of technical education during the past forty-five years and acknowledging without reservation the value of shop training, in my opinion conventional shop work or manual training no longer has a place in the curriculum of the technical school which seeks to prepare men for conditions confronting its graduates at the present day. The old formulas which served so well in the pioneer days of industry no longer fit in the new order of things and failure on the part of educators to grasp the significance of the upheaval

going on in the industrial world would be disastrous to the shop and correlative subjects. Industry in the past was effective but not efficient. A pioneer product grown to immense bulk on lines of least resistance it knew very little about its complex structure and was too busy to find out. Large markets not especially particular about price demanded organization for tonnage production rather than for economical production. Highly specialized service was not required in a large degree nor was it widely sought.

An inevitable readjustment to changing trade sociological conditions was destined, however, to sweep aside the old structure and supplant it with a new. While the usual processes of evolution had brought about certain changes a new note in industry was sounded in the late eighties, the real effect of which was not apparent for nearly a score of years. Then like a wave "Scientific Management" swept over the country as the topic of the moment. Not only industry but society as well developed an intense interest in this new specific for industrial conditions. Brushing aside all the clap-trap about scientific management which has arisen through misunderstanding of its real significance there stands the unmistakable fact that fundamental changes are taking place in the industrial structure. Principles which ruled heretofore are giving way to those founded upon broader conceptions and higher ideals. Accummulation of knowledge concerning fundamentals is both rapid and wide in scope. The old hazy images around which industry has worshiped are going down before definite standards of attainment, of organization, of methods. Experience moulded on traditional lines is no longer in such demand as that of the trained specialist, leaving the colleges no alternative but reorganization of courses of training if men are to be adequately prepared for the service which industry now demands of them. Such a reorganization presents its difficulties but it must come and quickly if it is to be effective.

SHOP INSTRUCTION AT UNIVERSITY OF ILLINOIS.

The relation between education and industry is indissoluble. The ideals of education are to develop men into better men, morally, mentally and physically; and if an educational system failed in this mission it would pass into decay as a useless feature of society. That it does not decay but continues to exert an ever widening influence in the development of civilization is a sign that education has not failed in the practical achievement of its ideals. The conclusion is also obvious that education has continued to meet the ever changing demands of society. Side by side with the evolution in industry which during the past century has been marked by striking changes from old forms to new, we see equally significant developments in educational methods. From the first, technical education and those special interests of society it aims to serve have enjoyed a particularly close relationship. The first has sought not only to solve technical problems by direct assistance in the research laboratory but also by offering training to young men for the special services required. Industry in return has taken an active interest in education and exerted a powerful influence on its development. The principal demand of industry on education is that it must be "practical" and courses in shop work seemed in large degree to fulfil this requirement. For forty odd years the college shop has flourished in an auspicious environment due to the enthusiastic support manifested by those interests which contributed so generously to the advancement of technical education. It has performed a great and useful service and won its right to a place in the higher institution of technical education but it stands to lose that place if early traditions continue as the source of inspiration for its activities. Originally the one bright "practical" spot in a group of "theoretical" courses, it is now one of the least practical if it offers no more than the traditional form of manual training. Performance of simple shop processes such as have been the rule in these courses without definite relation to elements of time and cost have little value in the training of men who must face

modern industrial conditions. Manipulative processes very properly have a place in secondary school training and some acquaintance with them in that environment is desirable but the college shop must aim beyond this and administer courses relating to the principles underlying the use of these processes in industry. An understanding of the principles of industrial economics, of shop organization, of production, and of executive control, is what industry demands of graduates today, and the shop laboratory largely will fail in its mission if it does not give at least some insight into the nature of these fundamentals.

The need for rehabilitating the ideals which heretofore inspired the work of the shop laboratories at the University of Illinois has led to changes in policy and methods which will be briefly described in the belief that they possess some degree of interest to the society. The reorganization was based on the following conceptions:

(*a*) That the college shop should serve in the function of a laboratory for the demonstration of the principles of industrial organization and management.

(*b*) That the development of manual skill in the use of tools and machinery is of secondary importance to training in the principles underlying the application of human endeavor to industrial operations.

(*c*) That the performance of the so called "fundamental mechanical shop operations" unrelated to the factors of time and cost is not essential in the training of the prospective engineer.

(*d*) That manual training more properly falls within the province of the well organized secondary school than in the higher institution of learning.

(*e*) That the shop laboratories must be "true to life," *i. e.*; correspond in all essentials of methods and equipment to commercial plants of recognized merit.

It is not within the province of this paper to enter into explanations or arguments in defense of the conclusions ad-

vanced above, as it is assumed these are accepted by educators who have correctly sensed the trend of the times. The Illinois plan had its origin in the belief that the function of the shop laboratories of technical colleges is to teach principles rather than practice; leaving the latter training to the secondary schools as their particular task. Further it was considered impossible to teach principles underlying shop processes in an effectual manner without the proper laboratory setting. That is, the machinery, the tools, and the methods, must be efficient and the shop laboratories organized to produce useful work cheaply and in quantity as a regular manufacturing plant. Such a program would introduce conditions into the shop laboratories closely approximating those of the industrial world and bring the student face to face with real problems of production and management. To solve these problems becomes the task of the student who assumes the role of executive and exercises the functions required in operating a manufacturing plant. This training develops those qualities which industry is demanding of college graduates of the present day namely; executive judgment, mental balance, initiative, and aggressiveness.

The success attending the administration of the plan depends, of course, on the same factors that enter into industrial operation but the store of knowledge which is available through the activities of scientific management removes the uncertainty of the issue provided the instructional staff is competent and there are adequate funds for development work. The university fortunately possessed both. In the practical development of the plan the shop laboratories were organized as a commercial plant with a regular line of products to manufacture. To the four existing departments namely: pattern, foundry, forge and machine, a fifth, erecting, was added. An eight-horse-power two-cylinder marine type gas engine of practical design was adopted as the first standard product. An operating plan for the production of this engine by the most efficient methods within the limits of

existing conditions was next worked out and put into effect. New machinery was added, new tools purchased and constructed, jigs and fixtures for rapid and duplicate manufacture designed and made, machinery regrouped, tool and stock rooms reorganized, offices for staff engineers provided in each department, shop operations standardized, instruction cards covering all standard operations arranged, and other details of a progressive shop policy put into effect. The scope of the mechanical organization was the same as in commercial shop practice when similar results are sought, and it may fairly be said that in respect to methods and facilities the shop laboratories are on an equal plane of efficiency with any well organized industrial plant engaged in manufacturing similar products. While great emphasis is placed on mechanical facilities for the rapid production of parts the object is not the attainment of production as a commercial achievement but to provide a medium for demonstrating the principles underlying modern manufacturing methods. It is essential that production be secured not for the sake of profit as in industry but as a laboratory exercise in problems of management. Under standardized shop conditions efficiency of management is expressed directly in the volume and cost of production. With the producing facilities a constant factor obviously the output secured by the various groups of students operating the shops in turn, will determine the degree of efficiency obtained by each group in the exercise of managerial functions. Students registered in shop work are divided into four groups or sections, each one of which is considered as a distinct operating unit. While all sections are engaged in the production of the same product the work of each is conducted separately and the efficiency of operation determined on this basis.

Registration of students in the shop courses averages from 300 to 350 per semester at the present time. The complete course such as taken by the mechanical engineers extends over four semesters or seventy-two weeks of nine hours per

week. The instructional staff consists of eight instructors, two of which are assigned to each of the four main departments. There is also a small force of mechanics and tool room attendants.

The laboratories are established in two one-story brick buildings of similar construction and size. Total floor area 34,000 sq. ft. Approximate value of buildings is $57,000.00. While not of modern construction or ideal arrangement the buildings serve their purpose very well. Shop equipment consists of a rather complete assortment of old and new machinery all of which is in excellent operating condition. Its present salable value is approximately $48,700.00.

With the shop laboratories "commercialized" in respect to methods and equipment, and an operating plan arranged for manufacturing a given product, there remains but to supply the operating forces to complete the essential elements of a manufacturing plant. The latter is accomplished by organizing the student groups into operating forces consisting of executives, clerks and workmen. Assignments to these posts are made arbitrarily but each student is moved periodically from one task to another so that during the course he performs all of the managerial and shop functions. In this way all students get, by direct contact, first hand experience with the various problems of management and production. From operating a machine the student may go to the office as production assistant, then back to the shop as material inspector, or to the stockroom as storekeeper or to the bench, or to the testing department, or to a different machine than the preceeding one. During one week the student may be acting as a shop hand, the next as "boss" of the shop. In the course of three semesters it is expected that every student will have performed all the essential functions of operating the shop plant and possess some understanding of the principles underlying its management.

The time allotted for the shop courses is necessarily inadequate for a complete demonstration of the great problem of

management which in practical life absorbs years of application. Consequently I have no illusions as to what may be accomplished in a few months while the students are in the shop laboratories. Certainly I do not expect that the shop training has the magic power of developing untrained men into full blown executives and managers. On the other hand I am convinced it is possible to develop conceptions of the fundamental principles of management that in later life will prove of immeasurably greater value than that of the traditional shop training.

The shop courses have been developed around the conception that the industrial process is in its elements a simple one of changing materials from one form to another by the application of human forces through the agency of tools. Management as the act of directing the course of these operations involved in this process is concerned with three elements, namely: (*a*) the worker or producing unit, (*b*) the material or the unit worked upon and (*c*) the equipment or the unit worked with. The shop instructional program is divided into three parts for the treatment of the elements just mentioned. This gives a simple and direct method for dealing with a large subject and tends to prevent unprofitable excursions into the realm of non-essentials of which there are legion. The specific features emphasized in the shop courses are listed below in tabular form and immediately following these will be briefly discussed as to aims and methods.

The Worker:

Types of Organization,
Functions of the Executive,
Relations to Industry,
Physical Facts,
Effects of Environment,
Methods of Reward,
Costs of Service.

The Materials:

Studies in Construction and Suitability,
Purchasing Methods,
Storage Methods,
Despatching Methods,
Ordering and Inventory Methods,
Transportation and Delivery Methods,
Costs of Materials.

The Equipment:

Selection and Specifications,
Maintenance Methods,
Operation Methods,
Production Methods,
Standardization Methods,
Testing and Experimental Methods,
Costs of Production.

Types of Organization.—The functional type of operating organization has been selected as the most effective for the shop laboratories and the reasons why are made the basis for a short discussion of the various types of organization and their special application in industry. A graphical representation of this organization is shown in Fig. 1. As shown by the chart the organization is purely functional. The operating staff consists of executives (called engineers for obvious reasons) with functional supervision over the various shop activities as follows:

Design.—Design of products, tools, jigs, facilities, etc., supervision over drawings, tracings, blue prints.

Materials.—Custody of all materials used about the plant; purchasing, storage, and delivery of same.

Production.—All problems of production including routing, despatching and making standard parts; supervision over working forces.

Standard Practice.—Time studies and rate setting of

standard operations; work schedules and instruction cards.

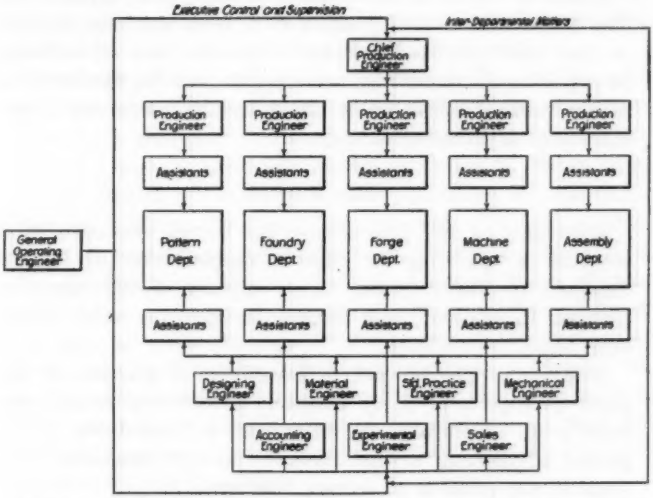


FIG. 1. Chart showing organization of the student operating staffs of the shop laboratories. The organization is purely functional.

Accounting.—Shop cost keeping and accounting incidental to manufacture of product; all shop records and audits.

Experimental and Inspection.—Testing of products; machine production tests; inspection of parts undergoing the process of manufacture.

Sales.—Publicity and advertising regarding product; sales of same; collections.

Maintenance.—Upkeep of plant and equipment; repairs; general shop conditions.

General supervision is vested in the office of general operating engineer which corresponds to that of works manager. The functions of this position are at present assumed by the director of the laboratories. The remaining staff positions

are assigned to students for periods of two weeks. In the second week the students next in line for the positions are "broken in" so the organization is virtually self perpetuating. The duties of each staff position have been carefully outlined so that intelligent and interested students have no difficulty in acquiring the knowledge necessary to perform the functions of the various offices or in grasping the particular lesson which the training aims to give.

The Worker.

Functions of the Executive.—The actual executive work involved in operating the plant is supplemented by lectures designed to illustrate the larger aspects of the executive problem in industry and thereby increase the value of the shop executive training.

Relation of the Worker to Industry.—A glimpse of this great question is given by means of lectures and actual shop experience. Naturally the treatment is limited but it has proved stimulating to that class of students especially interested in the problem of human relations.

Physical Facts about the Worker.—This subject also, from the instructional standpoint can be given but passing attention although it is one of great importance. The human machine and methods for conserving its health and vitality while engaged in industrial occupations are discussed in lectures. The matter of safeguarding the worker is emphasized by an aggressive policy of "safety first" in the laboratories. Instructions in safe practices are given and obedience to them insisted upon in the shop. Cautionary signs and safety notices are placed at various points where such are necessary. Machinery is safeguarded in a substantial manner and every precaution taken to prevent accidents. Students have a safety club with branches in all departments which has for its object the stimulation of greater interest in safety matters.

Effects of Environment on the Worker.—Lectures and

practical demonstrations are employed to illustrate the relation between environment and production. Constant effort is directed toward maintenance of a high standard of shop conditions in respect to cleanliness, light, water, ventilation and sanitation in accordance with good shop practice.

Methods of Rewarding the Worker.—The fundamental principle that the worker is entitled to earnings in proportion to his productive ability is demonstrated in actual practice by a plan of awarding grades according to efficiency in the production of work. All shop operations are standardized and definite time limits set for each. The actual time taken by students to perform shop operations as measured by the standard time allowed determines the efficiency of production. In industry the degree of efficiency attained forms the basis on which earnings are distributed to the worker but in the shop laboratories efficiency is used to determine the grade. Although the nature of the reward is not the same in both cases the principle involved is identical, so that the student is brought into personal contact with the modern system of rewarding labor.

The average efficiency of all students in a section determines the efficiency of that section as a work producing unit. Section efficiency is calculated once each week and posted on the bulletin board. Naturally a great deal of rivalry between sections is stimulated in this way, the effect of which is shown in the machine shop record for one semester as illustrated in Fig. 2. The successes and failures of the section operating staffs in the struggle to lead in efficiency are written graphically on the chart. This friendly contest brings out examples of high grade executive talent and stimulates the majority of students to do their best work.

Costs of Labor Service.—Labor costs of manufacturing the engine and operating the plant are computed by the accounting staffs. Work order cards are issued for all shop operations and student workmen record time "in" and "out" by time clocks upon these cards. The actual time and direct

labor cost are calculated from this card. Indirect and overhead charges are added and the total cost determined. A scale of hourly rates for different classes of service is employed for determining production costs, payrolls, etc. This feature

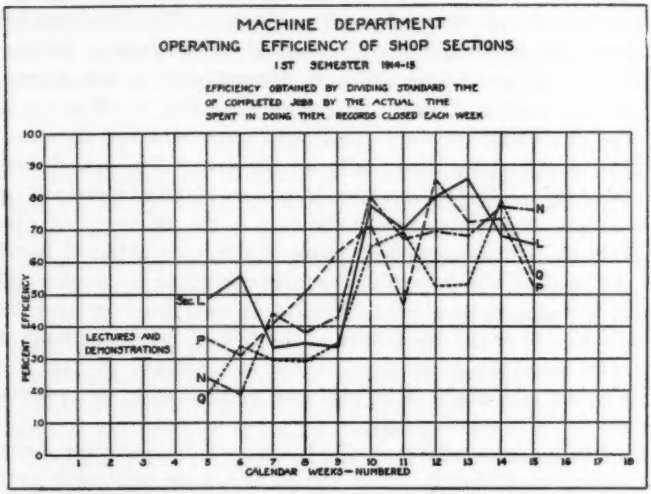


FIG. 2. Chart showing operating efficiency of shop sections in machine shop, for first semester 1914–1915. The upward trend in efficiency during the successive weeks is due to more effective management and greater skill in the operation of machines and tools.

of the course serves to give the student some aquaintance with the principles of cost keeping and more important still an insight into labor costs.

Materials.

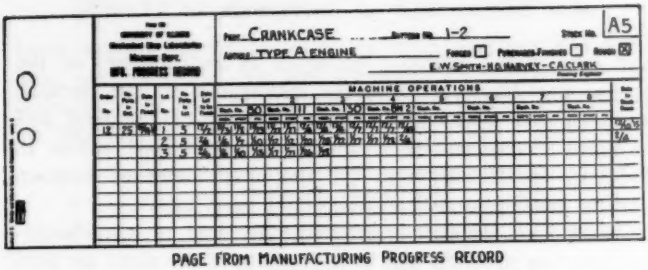
Studies in Construction.—Materials for use in gas engine construction are selected according to standards that prevail in commercial practice. Vanadium steel for connecting rods, aluminum alloy for pistons, nickel steel for valves,

and such metals actually employed in manufacture of the engine are discussed from the standpoint of cost, service, strength and workability. This study of the physical and chemical characteristics of the most widely used metals in industry coordinates with the shop experience of forging, casting, machining and testing of the same metals.

Purchasing Methods.—The materials used in manufacturing the shop products and in the upkeep of the plant are purchased by accepted commercial methods which serve as a medium for demonstrating this feature to the student. Questions of specifications, quotations, markets, trade prices, discounts, etc., are considered and discussed.

Storage Methods.—Materials (both raw and finished) are stored in modern stock rooms. These are in charge of staff material assistants who perform all work in connection with storage of materials and maintenance of stock records. Materials are issued on requisition only. Order and neatness is demanded in all stock rooms.

Despatching Methods.—Standard parts are despatched through the shops on a manufacturing schedule directed by the staff production assistants according to the number of engines to be made. As all manufacturing operations are standardized materials can be moved through the shops with precision and at the desired rate of progress if the shop organization is efficiently directed. To maintain a definite volume of production is the task of the staff production assistants. A record of the movement of parts through the shop is kept as shown on the sample page of the Progress Record in Fig. 3. The standard rate of production is charted and later the actual rate is posted as fast as individual operations are completed for the information of the production assistants. This graphical record is shown in Fig. 3. From this record the work of the production assistants is analyzed and all operating mistakes pointed out and remedies for same suggested. The relation between location of machines and production of parts is treated through lectures and labora-



PAGE FROM MANUFACTURING PROGRESS RECORD

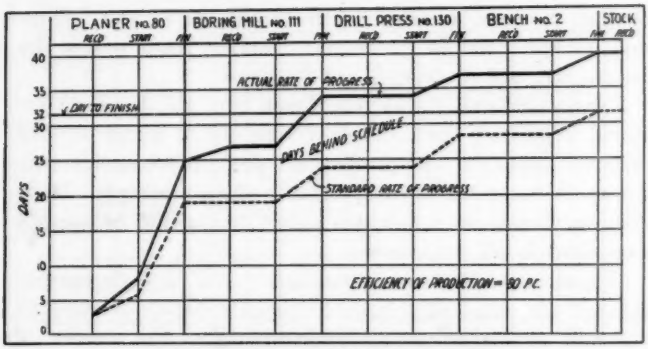
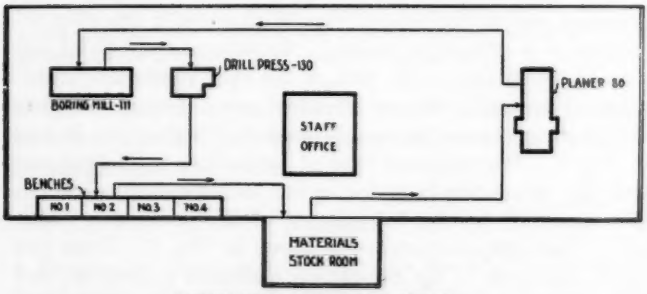


CHART SHOWING ACTUAL AND STANDARD RATE OF PROGRESS



ROUTING DIAGRAM SHOWING PATH OF TRAVEL

FIG. 3. The principles underlying the routing and despatching of parts in the manufacturing process are illustrated in practice, and graphical methods are employed in the study of these principles.

tory practice. Routing diagrams (Fig. 3) showing path of travel from one machine to another during the process of manufacture are developed in the study of the despatching problem. The staff offices are equipped with production despatch boards from which the staff assistants control the movement of parts. Training in the principles underlying despatching is real and therefore effective.

Ordering and Inventory Methods.—After the year's output of engines is decided upon orders for the necessary materials are placed by the staff material assistants on the various departments. Delivery dates and quantities are specified. All materials are ordered on requisition. Stores records showing stocks on hand, deliveries, orders, etc., are maintained by staff material assistants. Inventory of all stocks of raw and finished materials is made once a year to check the daily balances of the material records. The problem of material supply in manufacturing is brought forcibly to the students' attention by this feature of the course.

Transportation and Delivery Methods.—The usual shop facilities of overhead cranes, elevating trucks and common trucks are employed to move materials and studies are made to determine the expense of the various transportation methods.

Item.	Operation Routine.	Standard Time.
1.	Clamp chucking attachment to face plate	0.12
2.	Place casting in chuck and adjust to run true	0.08
3.	Place special boring bar in position on cross slide and 3 63/64″ boring tool in bar and bore out. Speed No. 5. Feed No. 3.	0.50
4.	Change boring bar end for end; place 1/2 × 1/2 tool in bar and face off and flare end as per sketch.	0.30
5.	Slack off chuck set screw, place 4″ reamer in tailstock and ream. Speed No. 10. Feed by hand.	0.12
6.	Remove casting from chuck and place in tote box.	0.04
7.	Remove all tools and fixtures from machine.	0.12
	Standard time in lots = Total pieces × 1.04 plus 0.24	
	Total standard time	1.28

Costs of Materials.—Material costs are calculated by the staff accounting assistants from the shop records and the value of the material in each gas engine part determined. This and the labor cost keeping is carried on simultaneously by the same staff by methods employed in commercial practice. The object of this feature of the course is to give the student a conception of material costs; the accounting work is incidental.

Equipment.

Selection and Specifications.—Equipment for economical production of gas engine parts is considered in lectures which coordinate with studies of the shop laboratory equipment in which its fitness or otherwise for manufacturing the engine is investigated. Trade papers and catalogs are used to supplement other data in developing an ideal layout of facilities for producing gas engine parts in the shop laboratories. While this problem is admittedly narrow in scope it is of topical interest and serves to illustrate the broad principles underlying the selection of manufacturing facilities for economical production of parts.

Maintenance Methods.—Repairs and upkeep of shop facilities and general maintenance of the plant are under the supervision of the staff mechanical assistants. Responsibility for the operating condition of tools, machines, belting and in fact all the material property of the plant is placed squarely before this staff. High standards of maintenance are demanded as in efficient commercial plants which imprints an important lesson on the students which is certain to be useful in later life.

Operation Methods.—It is intended that training in machine operation embody the latest and most efficient practice. Preparation included, selection of proper tools and machines, development of special tools, jigs and fixtures, determination of economical methods of production and standards of time for performing shop operations. Standard operating pratices for all shop processes of manufacturing the gas en-

gine are arranged in the form of instruction cards as illustrated in Fig. 4. Reference to this card which is typical

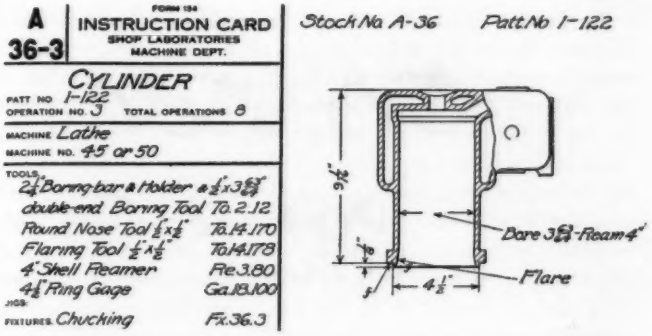


FIG. 4. A typical instruction card. Every operation in manufacturing the gas engine has been standardized and the practice arranged in the form of instruction cards. The number of operations standardized is over five hundred.

shows that the machine, tools, jigs, etc., are specified and also the successive steps in the operation with standard time allowances for performing the work. Operations are to be performed in exact accordance with the instruction card.

The marked increase in output which results from the use of standardized methods is illustrated by demonstrations in which shop jobs are performed in the old style "hit or miss" way and then repeated by the carefully prepared methods of the instruction card. The time lost in the first operation from waste motions and inefficiencies is readily recognized by students making studies of both. Stop watches are used to time the successive motions which are recorded on special forms for the purpose. Following the demonstration the data collected is carefully analyzed and conclusions drawn. Lectures on the principles of standardization applied to shop operations supplement the demonstrations and actual shop work. Skill in manipulation is not sought primarily but out-

put is encouraged in order to show the student the possibilities of large production by effective use of small intervals of time.

Production Method.—At the beginning of the year the Director issues an order on the shop laboratories for the manufacture of a certain number of gas engines. The size of the order is governed by the number of students registered in the shop courses and it represents the maximum output under existing circumstances. Delivery of the required number of finished engines in good order and up to the tests and specifications becomes the shop problem for the year. This calls for the united efforts of all the operating staffs and effective cooperation with the production assistants upon whom falls the responsibility of the final processes of machining, assembling and finishing the product. The production staff occupies an exceedingly important position in industrial organization as it controls the volume of production. Any inefficiency here is disastrous regardless of the manner in which the other operating staffs perform their work, consequently it is essential that the production staff is organized for efficient performance of its functions.

Production is directed by production assistants from despatch boards located in the staff offices. The boards are designed to show the production situation of the entire shop practically at a glance. As the status of each operation in respect to the predetermined production schedule is always before the staff the work can be directed intelligently through the shop channels. The boards are changed immediately upon receipt of information from the shop so they are always up to the moment. The ease of control over shop production and the effectiveness of the methods employed is forcibly impressed upon the students, and their interest and resourcefulness in this phase of the work has been very gratifying to the instructional staff.

The actual work of production is stimulated by the use of modern shop facilities, standardized tools, methods and proc-

esses. Jigs and fixtures are used largely in the manufacture of parts. A typical group of these is shown in Fig. 5. The

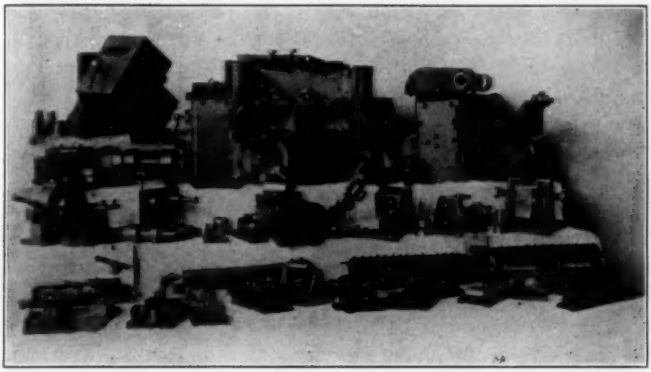


FIG. 5. A typical group of jigs and fixtures used in machining gas engine parts in the machine shop. There are over one hundred of these in this department alone. They are built by regular tool makers from practical designs. It is aimed to have special tools for every shop operation where such will reduce the time and cost of the work.

effect of modern production methods on output is illustrated by means of demonstrations in which operations are performed with and without special tools and jigs. All shop work is confined strictly to gas engine production and special jobs required about the plant. Students are assigned work by the production assistants according to the production schedule without regard to its nature. Parts are manufactured in lots, the size of the part determining the number in the lot. With some of the smaller parts fifty pieces will constitute a lot. The various lots go through the shop intact, the different operations being performed by students in turn. That the work is useful and conducted in a practical way makes a strong appeal to students taking the course.

Standardization Methods.—In preceding paragraphs atten-

tion has been called to the use of standard tools, parts, methods and practices in the shop laboratories. In respect to standardization of these items the same shop policy has been followed as in the best commercial practice. It is the aim to maintain standard shop conditions for the purpose of demonstrating the principle of standardization to manufacturing processes. Standards based on any but accurate and conclusive data have no value—in fact inaccurate standards introduce some very dangerous elements into shop operation. Methods of analyzing shop processes into the elementary details and then of correctly interperting the accumulated information are taught by precept and laboratory practice. In the shop, time studies are made by a staff of standard practice assistants of shop operations on the gas engine using stop watches for timing the successive motions employed in performing the work. Times are recorded in hundredths and thousandths of hours. These studies are repeated by different students until a certain number have been made. They are then carefully compared item by item and a tentative work schedule prepared. If subsequent examination confirms the accuracy of the data it is arranged in the form of instruction cards.

Testing and Inspection Methods.—Inspection of parts undergoing the process of manufacture is conducted by a staff of inspection assistants. As efficient inspection is an important detail of shop operation it is given considerable attention in the shop courses. Inspection is made of every part at the completion of each operation. Thus if six operations are required to complete a part it is given six inspections which leads to rejection of the part for defects in material or dimensions before subsequent work is done upon it. Each department has an inspection office equipped with the necessary inspection facilities. Views of a typical office and facilities are shown in Fig. 6. Inspections are rigid and parts not finshed within the limits allowed by the inspection standards are rejected summarily. Facilities for inspection are com-

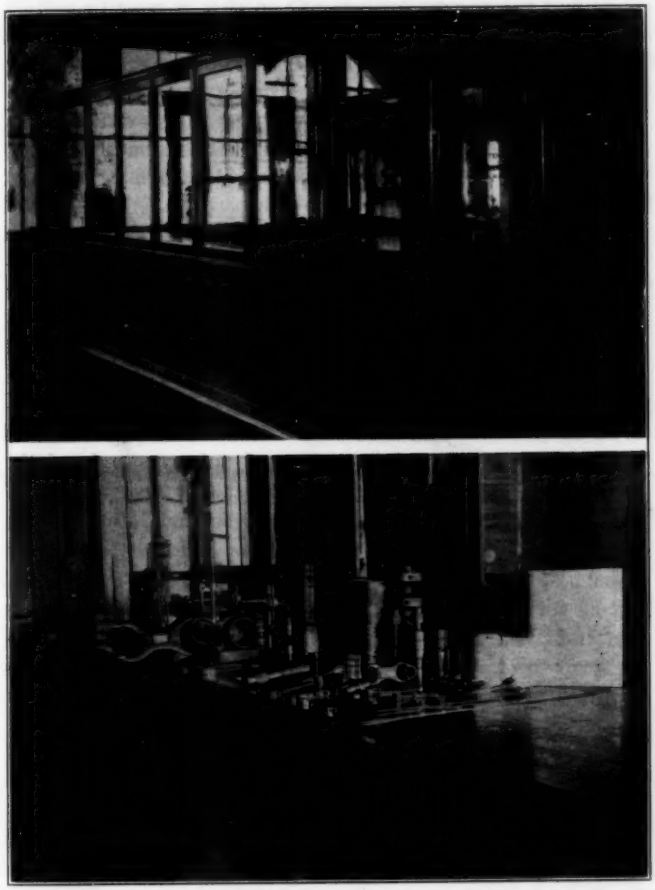


FIG. 6. Exterior and interior views of inspection office in machine department. The construction is typical of all staff offices. Testing appliances correspond in type and number to industrial practice. The tote boxes containing the work are below the bench in the lower picture.

plete and the instructions specific so that if poor inspection occurs it is traceable to the student responsible. In the course of the training of inspection students use practically all of the important types of plug, ring, snap, dial and surface gauges, micrometers, sceleroscope, gear tester and testing machine in the operation of checking dimensions, hardness, strength and accuracy of parts made of the most common metals used in manufacturing.

The same staff conduct tests of the gas engine and also tests of machines in drilling and turning metals. After assembling, gas engines are delivered to the testing department for test. Here the engines are "broken in" on a special testing rack for several days and a careful record made of all defects, should such appear. Test for horse-power rating is then made and the engines returned to the assembly department for painting and finishing.

A high production drill press and a heavy engine lathe have been equipped with dynamometers for the purpose of demonstrating the performance of drills and lathe tools in the production of work, the power consumption, and other important data. This development in the shop courses has not as yet taken definite form but it is mentioned here as a matter of interest. There are large opportunities in experiments of this kind for rounding out the experience of students with machines and materials which would be impossible by any other method.

Costs of Production.—The functions of the staff of accounting assistants in shop cost keeping has been explained previously in connection with the items of labor and material. The costs of labor and materials plus overhead and fixed charges constitute the total expense of production. This figure is determined for the gas engine to give the students some experience in cost keeping but principally to pass the great question of cost in review before them—as cost is the rock upon which industry breaks, if it breaks at all.

The shop courses at Illinois are more than a matter of jigs

and instruction cards. These and other elements of modern industrial processes mean little in themselves. Their application is the important thing. In the shop courses the possession of modern equipment and methods does not insure effective training in shop practice, but the latter is impossible of achievement without the aid of suitable methods and equipment. In Illinois the method of attack was directed first at the shop, its equipment and methods with the object of developing a real laboratory for demonstrating the principles of efficiency through the practice of these principles.

THE THEORY OF COLUMNS*

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The theory of columns as given in text-books on the strength of materials is defective in two respects.

(*a*) The beam formula, $EI = M\rho$, derived explicitly for a case in which there are no longitudinal loads, is applied to a case in which there are. This means that the neutral axis of a column section passes through the centroid, and that fiber stresses arise only from bending; both conclusions are obviously untrue.

(*b*) The use of an approximate value of the radius of curvature ρ leads to a load formula which is independent of the deflection. Some writers, in spite of numerous theoretical† and experimental‡ investigations to the contrary, have been willing to infer from this that the deflection actually is independent of the load.

The following method of investigating columns is similar to that used for beams. To simplify the analysis

* The substance of this paper is taken from an article by the author in the *Stevens Indicator*, January, 1912. Eq. (3) of that article is wrong in sign; this affects the signs but not the significance of some of the subsequent equations.

† The history of the problem is interesting. T. Tredgold, 1822, although not the first to notice that Euler's theory neglected direct compressive stress, was perhaps the first to calculate the position of the neutral surface. He believed however that it was parallel to the centroidal surface. J. P. von Heim, 1835, E. Lamarle, 1846, F. Grashof, 1878, and others independently established the same differential equation of columns; eq. (10) of this article. For details see Todhunter and Pearson, *History of Elasticity*, 1886; further references are in Love, *Lehrbuch der Elastizität*, 1907, and Mehrtens, *Statik und Festigkeitslehre*, 1909–1912.

‡ For example, *Watertown Arsenal Report*, 1893.

i. neglect shear stress,

ii. neglect transverse distortion in comparison with deflection,

iii. assume linear distribution of normal stress on cross-sections,

iv. assume small deflection.

The problem then is to find the force P that will hold a column in equilibrium for a given deflection. In Fig. 1 part of the column is represented as a free-body under the action of P at the end, and normal stresses p on any cross-section of area A. The ends are pin-connected.

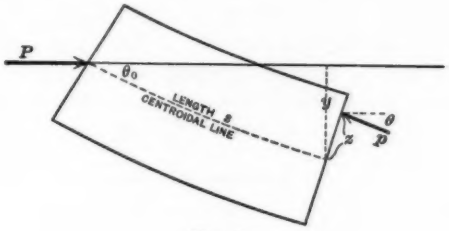


FIG. 1.

Equilibrium requires

$$P = \int p dA \cos\theta, \tag{1}$$

$$Py = \int pz dA, \tag{2}$$

$$o = \int p dA \sin\theta. \tag{3}$$

Since cross-sections remain plane, assumptions i and iii, the relation between p and z can be found from the way in which a transverse slice of infinitesimal thickness is strained. Fig. 2 shows two sections, originally parallel, rotated about axes distant ζ and $\zeta + d\zeta$ from the centroidal line. These are the axes at which there is no stress; the surface through them is the *neutral surface*. It is the locus of zero stress rather than of fibers that remain unstressed.

If ρ is the radius of curvature of the centroidal line,
length of original filament is $(\rho+\zeta)d\theta+d\zeta d\beta$
length of strained filament is $(\rho-z)d\theta$,

whence by Hooke's law

$$p=E\frac{\zeta+z}{\rho+\zeta}. \tag{4}$$

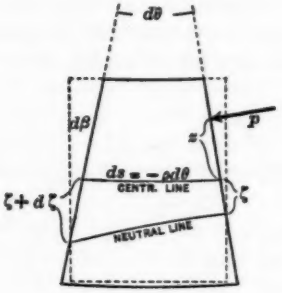


FIG. 2.

By means of (4), eqs. (1), (2), (3) become, since θ is constant for any plane section,

$$P=\frac{EA\zeta\cos\theta}{\rho+\zeta}, \tag{5}$$

$$Py=\frac{EI}{\rho+\zeta}, \tag{6}$$

$$0=\frac{EA\zeta\sin\theta}{\rho+\zeta}. \tag{7}$$

From (7), $\sin\theta=0$ or $\zeta=0$ or $\rho=\infty$, all of which are evidently untrue. But if we had not neglected shear, (3) and thus (7) would have had some quantity greater than zero in the left member. Furthermore, since θ would not have been constant the right members of (4)–(7) would have been

different. Let us assume however, in view of not knowing what else to do, that (7) is satisfied closely enough when the deflection is small. In this case we may take $\sin\theta = 0$ and $\cos\theta = 1$. With these approximations (5) and (6) yield

$$\zeta y = k^2, \quad [I = Ak^2], \tag{8}$$

where ζ defines the position of the neutral surface.

From (4), (6), and (8)

$$p = \frac{P}{A} + \frac{Pyz}{I}, \tag{9}$$

which familiar result indicates the superposition of direct compressive stress P/A, due to the load P, with compressive (or tensile) stress due to the bending moment Py. If (9) is obtained independently by the principle of superposition, as it can be, (8) follows from it by putting $z = \zeta$ when $p = 0$.

From (6) and (8)

$$\rho = \frac{EI - Pk^2}{Py} = \frac{1}{\lambda^2 y}, \tag{10}$$

where

$$\lambda = \frac{P}{EI - Pk^2}.$$

Since the elastic line is concave toward the axis, $d\theta$ is negative when ds is positive

$$\therefore \ \rho d\theta = -ds.$$

Substituting this in (10), differentiating, and using

$$dy = ds \sin\theta,$$

we get the differential equation of columns

$$\frac{d^2\theta}{ds^2} = -\lambda^2 \sin\theta. \tag{11}$$

For hinged ends the boundary conditions are

$$\theta = \theta_0, \quad \frac{d\theta}{ds} = 0, \quad \text{for} \quad s = 0, \quad s = l.$$

Eq. (11) resembles the pendulum equation and is a particular case of Kirchhoff's analogy between the equations of equilibrium of a thin rod and the equations of motion of a rigid body.

By the usual transformations the integral of (11) is reduced to the elliptic integral

$$l = \frac{2}{\lambda}\int_0^{\pi/2} \frac{d\phi}{\sqrt{1-\mu^2\sin^2\phi}}, \quad \left[\mu = \sin\frac{\theta_0}{2}\right],$$

where l is the length of the centroidal line – not of the original column.

Although θ_0 is assumed to be small it cannot reach zero without, as in the analogous cases of the pendulum, invalidating the first order differential equation. If we had put $\sin\theta = \theta$ in (11) we should have got a correct enough quantitative result, but one that would not even approximately describe the character of the real solution any more than the usual pendulum formula shows the period to depend on the time. The distinction between a quantitative and a qualitative approximation is important. Therefore while tables of elliptic integrals show that l for $\theta_0 = 10°$ differs by only 0.2 per cent. from l for $\theta_0 = 0°$, it is necessary to obtain the relation between l and θ_0. To terms of the second order it is

$$l = \frac{\pi}{\lambda}\left(1 + \frac{\theta_0^2}{16}\right). \tag{12}$$

Hence from (10)

$$P = \frac{\pi^2 EI\left(1 + \frac{\theta_0^2}{8}\right)}{l^2 + \pi^2 k^2\left(1 + \frac{\theta_0^2}{8}\right)}, \tag{13}$$

which is the formula for small deflections of a pin-connected column. Similar formulas, as in Euler's case, are found for other end conditions.

For every positive value of θ_0 there is only one value of P, and conversely; that is, there is a one-to-one correspondence between the load and the deflection. Since there are no points of inflection on the elastica defined by (12) it is safe to infer that every configuration of one bow is stable for the load given by (13) provided

$$P > P_0 = \frac{\pi^2 EI}{l^2 + \pi^2 k^2}, \tag{14}$$

where l is now the length of the (compressed) column. Any imparted deflection will disappear if $P < P_0$. This is true of course only in so far as our assumptions are legitimate. It remains to determine a priori within what limits theory may be expected to give results reasonably in accord with experiment. Any theory that does not enable us to do so is defective as theory be its value ever so great as a computing device. Here is one of the weak points in our inherited tradition of columns.

The greatest fiber stress must remain within the elastic limit. To determine whether this criterion defines the latitude of applicability of (13) eliminate p from it by means of (9). There results

$$\frac{l}{k} = \pi \left[\frac{E}{p} \left(1 + \frac{yz}{k^2} \right) - 1 \right]^{\frac{1}{2}} \left(1 + \frac{\theta_0^2}{16} \right).$$

Consider for example a circular wrought iron column for which

$$p = 25 \times 10^3 \text{ lbs./sq. in.}, \quad E = 25 \times 10^6 \text{ lbs./sq. in.}$$

Here $z = 2k$, and if the maximum linear deflection is of about the same magnitude as k, or if there is slight initial bending or lack of alignment of this amount, $y = k$

$$\therefore \quad \frac{l}{k} = 17 \left(1 + \frac{\theta_0^2}{16} \right), \text{ [nearly].}$$

Hence the slenderness ratio l/k must exceed 170 for bending to be possible, otherwise the material will fail by direct compression before deflection occurs at all. Experiment verifies this. For such a large ratio, (14) reduces to

$$P = \frac{\pi^2 EI}{l^2},$$

which gives the load under which a *long* pin-connected column will remain straight. Each greater load produces a definite amount of bending until the elastic limit of the material is reached.

The foregoing method is crude and bears about the same relation to a rational theory of columns that the engineers' treatment of torsion does to Saint-Venant's great memoir of 1855. It would be gratuitous to expect it to account for the behavior of such an extremely complicated mechanism as a deformable strut, in which lateral, cross sectional, and local strains are of far greater magnitude than those arising from bending.

HYDRAULICS LABORATORY.

BY HARLAND C. WOODS,

Professor of Civil Engineering, Roberts College, Constantinople.

The excellent report of the Committee on Civil Engineering Instruction has again shown among other things the great diversity that exists in the courses given in our American Institutions. This diversity is noted not only in the list of courses but also in the substance of those courses that have come to be regarded as standard. This statement applies to the laboratory courses more than to the theoretical ones. Neither the size of the school nor the amount of the equipment seem to be any indication of the extent of work given the student in the laboratories. As one may gather from the report mentioned some of our smaller institutions judged from size, appropriations, age, etc., give much more extensive courses in Materials Testing for instance than some of the older, larger and better equipped ones. We are coming to realize that courses should be standardized so that if there is any desire students may do as they are able to do in Germany —move from one school to another at the end of any semester. There are in every laboratory course certain fundamental requirements to be fulfilled, *i. e.*, the basic principles of the theory involved should be well illustrated and tried out. Whether the more extensive work given in some laboratories does this better than shorter courses which are the rule elsewhere, the Joint Committee on Engineering Education will no doubt tell us when their report is published.

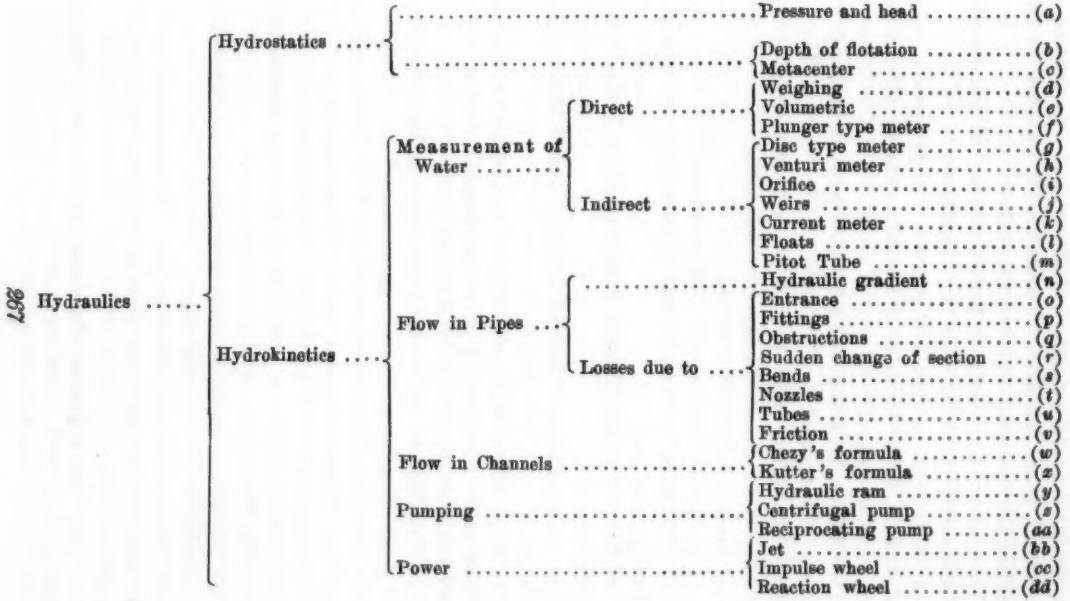
Hydraulic laboratories are relatively recent divisions of technical equipment and the instruction there seems to be in a particularly chaotic state. Many students are graduated in civil engineering who have never had any experimental work in Hydraulics while others have the experience acquired

on as many as sixteen different experiments. The average number of experiments given in the fourteen colleges represented in the table forming part of the committee's report is 11.5 while the list of various experiments given by these same fourteen colleges totals 25. Just what this means it is not the purpose of the writer to try to decide. It is patent, however, in this as in other courses that a certain amount of work ought to be covered by the undergraduate but that none of his already overcrowded time should be used on work that would better be reserved for special investigation. The disputable question is "Where lies the line between undergraduate work and special investigation." Teachers who are interested in irrigation will say, "here," others making a specialty of water-supply will say "there" while the water power expert will say, "No, I disagree with you both. It is at this point."

Robert College Engineering Department being new it has been necessary to answer this question as intelligently as possible in order to proceed with the design of our laboratories and to make that design such that the work which it would be possible to give would fulfill the fundamental requirements of such laboratories. Too many laboratories due to the nature of the growth of the school, uncertain finances, and other reasons, have not been designed but have just "grown." The result is a conglomeration of apparatus, a good share of which is almost worthless. Much of the remainder will serve several purposes "fairly well." There may be one or a *few* more pieces which ideally serve some definite purpose and might take a place in a systematic layout of laboratory equipment.

Our hydraulic laboratory is not entirely equipped but the process is so far advanced that good results are already being obtained. The line of reasoning and method of analysis by which the desirable equipment has been decided upon may be of interest.

By "desirable equipment" is meant that which is best adapted for experimental work on what to the unbiassed mind


Hydraulics
Hydrostatics
Pressure and head (a)
Depth of flotation (b)
Metacenter (c)
Hydrokinetics
Measurement of Water
Direct
Weighing (d)
Volumetric (e)
Plunger type meter (f)
Indirect
Disc type meter (g)
Venturi meter (h)
Orifice (i)
Weirs (j)
Current meter (k)
Floats (l)
Pitot Tube (m)
Flow in Pipes
Hydraulic gradient (n)
Losses due to
Entrance (o)
Fittings (p)
Obstructions (q)
Sudden change of section (r)
Bends (s)
Nozzles (t)
Tubes (u)
Friction (v)
Flow in Channels
Chezy's formula (w)
Kutter's formula (x)
Pumping
Hydraulic ram (y)
Centrifugal pump (z)
Reciprocating pump (aa)
Power
Jet (bb)
Impulse wheel (cc)
Reaction wheel (dd)

are the fundamental principles of the subject. To determine what were those fundamental principles in the case of hydraulics the following outline was made.

The principles are lettered for convenience of reference in the discussion given below of the experiments.

(*a*) Apparatus to show that pressure is dependent on head and that the size of the tank or reservoir does not affect pressure. Experiment 1.

(*b*) Make a float answering specifications for use in Bosphorus. Experiment 2.

(*c*) This belongs more to a course in marine engineering than any other and is not experimented with.

(*d*) Used in other experiments.

(*e*) Calibration of reservoir. Experiment 3.

(*f*) Principles involved in this type of meter are brought out in (*g*) and (*aa*).

(*g*) Test of 13 mm. Dreyer, Rosenkranz and Droop meter. Experiment 4.

(*h*) Calibration and test of 2-inch Venturi Meter. Experiment 5.

(*i*) Experiments on round, elliptical, square and triangular orifices under heads up to maximum possible and on a low head rectangular orifice. Experiment 6.

(*j*) Experiments on rectangular, trapezoidal, triangular and proportional-flow Weirs. Experiment 7.

(*k*) Experiments on Bosphorus with Price electric current meter and Haskell direction meter. Experiment 8.

(*l*) Experiments on Bosphorus. Experiment 9.

(*m*) Determination of velocities in the cross section of a stream by Pitot tube. Experiment 10.

(*n*) No special experiment made on this as the idea is well brought out in (*h*) (*r*) and others.

(*o*) Not experimented on as no ideas are brought out which are radically different from those in others on which experiments are made.

(*p*) Find loss in elbows of several different sizes. Experiment 11.

(*q*) Not given for same reasons that (*o*) is not given.

(*r*) Find loss due to sudden change from a large to a small section and vice versa. Experiment 12.

(*s*) Find loss in a pipe bent to a uniform radius. Experiment 13.

(*t*) Not experimented on as this would seem to be a case more suitable to the field of special research.

(*u*) Experiments on standard, converging, diverging and compound tubes. Experiment 14.

(*v*) Find loss due to friction in 160 ft. of pipe. Experiment 15.

(*w*) and (*x*) Cases for special investigation.

(*y*) Test of hydraulic ram. Experiment 16.

(*z*) Test of Pulsometer Steam Pump Co. centrifugal pump. Experiment 17.

(*aa*) Test of Worthington Triplex motor driven pump. Experiment 18.

(*bb*) Principles brought out in next experiment.

(*cc*) Test of Pelton wheel. Experiment 19.

(*dd*) Preferably this should be divided into two experiments in both of which the range of head should be the same. One experiment should be on a turbine designed for low heads and the other experiment on a turbine designed for high heads.

The class is as usual to be divided into squads. Every squad cannot do all of the work laid out above. In experiment 7 for instance one squad would work with one weir and another squad with a different one. In this way the work can be divided up in several of the experiments so that each squad will get all the data for plotting curves and making complete reports without spending an excessive amount of time in actual laboratory work. Nevertheless each student will get the laboratory experience involved in each of such experiments.

The outline shows that about twenty-one experiments are desirable for an undergraduate course in experimental hydraulics for civil engineering students. Assuming that each experiment will take one laboratory period this course demands

twenty-one laboratory periods. With eighteen weeks in a semester allowing one week for final examinations and two periods lost on account of vacations a two-hours course would give thirty-two full periods. While several of these experiments may take more than one period others will require less and by a careful grouping of them the shorter ones may be scheduled with two to be done at the same period and the actual time of the student in the laboratory will be used efficiently. It takes just as long to come to the laboratory, get into overalls, get out of overalls at end of the experiment and go home, for an experiment requiring one hour of work as for two experiments each of which takes one hour of actual work. Therefore, by careful supervision and grouping of the experiments it is possible to reduce the number of times that the student must appear in the laboratory to less than twenty-one. So it would seem that the work outlined is not too much to expect in a two-hours course.

As a further aid to the efficient use of his time on the part of the student the writer believes in giving students rather definite written directions as to just what they are expected to do. At the beginning of the semester each student is handed a report outline which is to be used as a general guide in making out reports. An excellent form of such a set of directions has been given by Professor Judd on page 274, Part II, Vol. XX of the *Proceedings* of this Society. The student is given to understand that this outline is not a hard and fast standard to be followed in every case but merely a general guide to show him the nature of the reports that he will be expected to hand in. Then for each experiment there is a special set of directions given to the student about one day previous to the time of making the test.

The following is an example of such a set of directions:

The student is expected to read up on the test and come to the laboratory prepared to go ahead in an intelligent way with the performance of it. The assignments should not be made nor the directions given out more than one week in advance in order to secure the best results.

ROBERT COLLEGE.

HYDRAULICS LABORATORY.

INSTRUCTIONS FOR CALIBRATION OF WATER METER.

Take note of the make, type and size of the meter.

At first run the water through the meter at the maximum pressure at which it is possible to get full flow. Take note of the reading of the meter before opening the valve and weigh *all* the water passing through it. The valve should be opened and closed as quickly as possible in order to maintain the pressure on the meter for as much of the time as possible. Make other runs at pressures of $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ of the maximum. Run one cubic meter of water through at each pressure.

Column headings on the log sheet should contain the following:—Main pressure, service pressure, loss (lbs./sq. in.), time, (seconds), tare weight (lbs. or kilos), gross weight, total discharge in (*a*) net weight, (*b*) cubic feet or meters, actual discharge (cu. ft./sec. or cu. meters/sec.), meter readings (*a*) initial, (*b*) final, indicated discharge, meter coefficient.

Plot curves as follows:—Main pressure-discharge, main pressure-meter coefficient, discharge-loss.

Note if the gear trains are accurate and from the curves determine (*a*) for what main pressure the meter coefficient is one, (*b*) the discharge at that pressure and (*c*) the loss in pressure.

In the matter of setting up the test apparatus the writer is of the opinion that often too much of this is left to the students. The familiar argument is always used that the student gets more out of the experiment if he does all of such work for himself. But the point is apt to be overlooked that the majority of students have never had any experience with the apparatus involved and sometimes have never seen and often before the time that they took the theory have never even heard of such a thing. Many of our students in the western institutions especially come from farms and small villages where the chance to acquire first hand knowledge of engineering machinery and laboratory apparatus is practically nil. Students in surveying classes are not sent out to the field to perform an exercise with a new instrument without very definite instructions as to the purpose of the exercise, necessary equipment, method of procedure, form of notes and the results to be obtained. Only so can the student learn the cor-

rect and efficient way to do certain things, the correct way to register the work done and the results obtained. Knowing these facts the writer has little sympathy with those teachers who send undergraduate students into a laboratory to work on some assigned experiment with only a statement of the problem and directions that they must set up their equipment, work out their own scheme of procedure and make a report to cover all. Unless the instructor personally supervises practically every step of the work or unless there may happen to be a student in the squad with enough practical experience to enable him to do such supervision, the apparatus is more than apt to be improperly adjusted and connected. If the error is found before the experiment is begun the time lost in disconnecting and making proper new connections or in readjusting, comprises the total loss in hours of work but very often such error is not found until the squad has spent more or less time in experimentation. In either case the most important thing is not the amount of time lost and the useless effort expended in work. More serious is the disheartening effect on the student and the consequent loss of interest in the course.

According to the writer's ideas the only true reason for having the student do so much is failure through laziness or lack of time on the part of the instructor to get the important part of such work done ahead of time or a lack of appreciation of the value of time to an engineering student. We often hear teachers make statements in connection with such work the idea of which is "Let the student work at it. He will learn something while at work." He does learn something but the point is that if given the proper start and directions he can learn the same things in less time. In the field of original research things can be learned only by going over every bit of the ground but with the undergraduate "Pilgrim" our purpose is to give him as extensive and complete an understanding of his province of the world of knowledge as it is possible to do in the time allowed. So we should point out to him the pitfalls of trifling errors and the ever deepen-

ing marshes of serious mistakes that are found at the sides of the solid road of correct theory. Only should we leave him alone when he is on that road and started in the right direction. It is all right to let a young boy who has plenty of time hanging heavily on his hands play with practical toys and learn as much as he can while so doing but our young men are or should be in our classes and laboratories to get as much as they can in the time they are in college. Therefore, in order that the student may use his time more efficiently he should have quite clear directions as to what he is to do and how to it. The instructor must use good judgment as to when to withhold advice and assistance in order that the student may develop initiative and self-reliance.

METHODS OF TECHNICAL EDUCATION.

BY GUSTAVUS F. SARGENT.

BOSTON ELEVATED RAILWAY COMPANY.

The educators of today have made a serious mistake in allowing the boy of seventeen or eighteen to assume the arduous duties of a technical school education. Hardly past the formative period of manhood, the boy is not physically or mentally equipped to understand the task of learning the theory of science and much less can he judge the correct branch of science to follow. Seldom does a boy know his real bent even after graduation from college.

It has been stated that only ten percent of the graduates of technical schools are mentally adapted to follow their chosen professions. They have crowded into their heads a mass of theory, which is not fully understood, but which can be applied in a more or less accurate manner. This is not science or scientific! The solution of technical problems is comparatively simple but the practical engineer not only has to solve it but he must first prepare the problem—an impossibility to the inexperienced. The technical school graduate, not having had the practical training in the drudgery of engineering, has no association of ideas between theory and practice. He must, therefore, as soon as he is graduated, start in at the bottom at low salary and learn the practical side of his work. Meanwhile he is forgetting to apply his theory.

The question is: Has the theory really been absorbed? No! Not in many cases. Graduates, even, who have high standing are really deplorably ignorant when it comes to the application of theory. The quick succession of varied courses during the four years of college training allows no time to select and absorb the essential. In fact the young brain does not know the essential by sight.

Another disappointing phase of the situation is the case of

a graduate who finally gains a practical engineering education only to realize that it is not his proper life work. What is he to do? Most men continue in the line of youth's error with mediocre success. Some are enabled by circumstances to drift into the right channel. Another method of teaching the young man to determine his capabilities should be found by our educators. One great cause of the failure of technical graduates to become real engineers is their aspirations to positions requiring superior intellect with little work and big pay. The man with the professional title seems to have a more dignified position in life than the business man. While the latter may have perfected himself to a high degree in the study of human nature and life, he is only tolerated by the intellectual snob. Youth is not fitted to select his future career under present conditions. After passing college entrance examinations, the boy's next course should be in "Life." This may be accomplished in many ways. He may go to work but chance rarely affords the right opportunity. The secondary technical schools are doing some experimental work along this line by arranging alternating periods of two weeks' school work and two weeks' practical work. The student is enabled also to follow the general line of his school work by the cooperation of these schools with various great industrial enterprises. The positions open to this sort of work are limited and the establishment of such a universal system is impractical. One of the foremost educators of the day has proposed a totally new idea, which is quite practical. He said: "Let the youth, after finishing high school be apprenticed to the Government for one year for the purpose of doing the practical government work of civil, mining, electrical and railroad engineering, forestry, army, navy and medical service." After such a broadening experience of one, two, or even three years' duration, a boy could choose his future career with some degree of assurance. A college course could then be pursued with understanding and after graduation the technical world would have a supply of real engineers,—fewer in numbers but better in quality.

ELECTRICAL LABORATORY EQUIPMENT AT THE UNIVERSITY OF MISSOURI.

BY KERR ATKINSON,

Instructor in Electrical Engineering, University of Missouri.

In response to the request of the Laboratories Committee for descriptions of special laboratory equipment and methods, there are here presented a few of the features found in the electrical laboratories of the University of Missouri. It is not intended to describe the laboratories as a whole but only such equipment as might prove of special interest.

All connections necessary in the routine work are made by means of plug cords and sockets. Terminals of all machines, rheostats, and meters are equipped with brass receptacles (Fig. 1). These were made in quantity by a screw machine company at a cost of 7¾ cents apiece with two nuts. They are small, cheap, and readily applied. Leads from windings of machines are permanently gripped between the two flat nuts and temporary connection is then made by inserting plugs into the holes reamed in the sockets. If desired, temporary connection to wires not equipped with plugs may be accomplished by clamping the wire under a third nut. Connection to sockets is thus not limited to plug cords only.

The plug cords are made from number 6 flexible wire having on each end a short length of ⅜ inch brass tubing split down one side (Fig. 1). Wooden switch handles pinned to the tubes facilitate manipulation and minimize the danger from shock.

To connect to new or special apparatus which may not be provided with the standard receptacles, the special attachments shown in Fig. 1 may be slipped on standard plug cords and inserted in binding posts or clamped under nuts. Connectors consisting of brass tubes enclosed in insulating cylinders serve

to join two or more plug cords to obtain wires of extra length.

These connections are used to carry currents up to 50

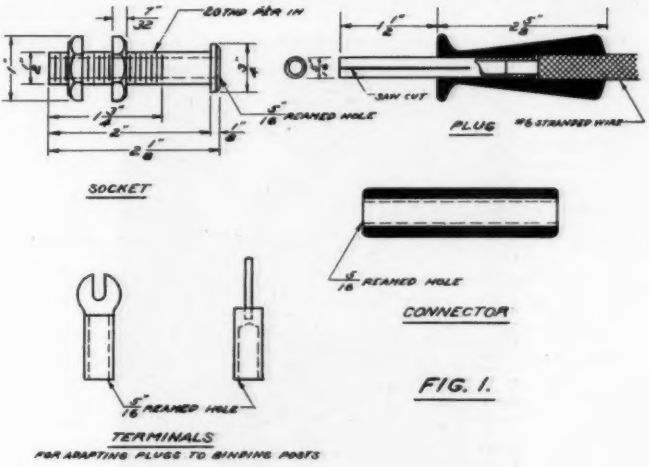


FIG. 1.

amperes continuously and 100 amperes for short periods. They give excellent service and have reduced the time required to make connections by the old method of skinning wires and inserting in binding posts or under nuts by at least 75 per cent.

The terminals of machines and meters used in routine experiments together with necessary connections to power supply and switches are wired to sockets and grouped on slate panels near the apparatus. Two panels (Fig 2) are mounted at each set, one carrying the terminals just mentioned, the other carrying the circuit breaker, switches, control apparatus, and meters which are wired to the sockets on the first panel. This brings all terminals employed in one experiment within easy wiring distance of each other greatly facilitating the work of connecting. The material for these panels, ex-

cluding meters, circuit breakers, and starting rheostats, but including all other apparatus, wire, and supports, was obtained at an average cost of $30 per panel.

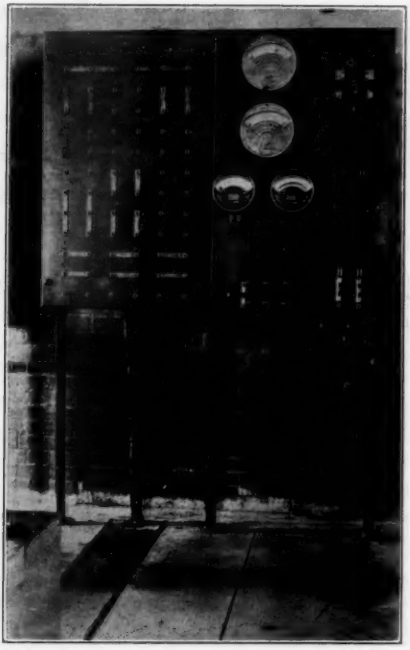
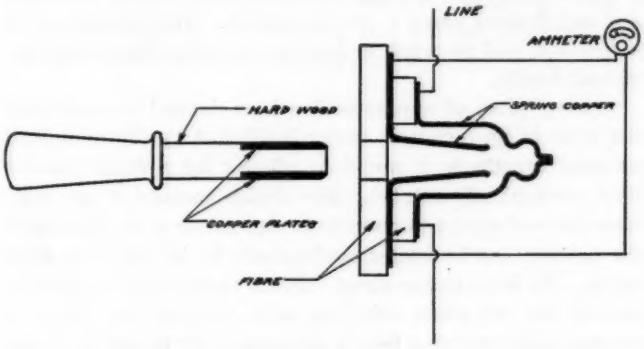


FIG. 2.

Where it is necessary in one experiment to measure the currents in several circuits, it was found convenient to use a single ammeter and a set of ammeter "jacks" (Fig. 3). The inner fingers of the jacks connect to the meter as shown. One pair of outer fingers connects in series with each circuit whose current is to be measured. By inserting a rectangular wooden plug carrying copper plates on two sides, the inner fingers

will be connected to the corresponding outer fingers and the latter forced apart, thus inserting the ammeter without breaking the current. To read the current in another circuit it is only necessary to remove the plug and put it in the corresponding jack. The jacks are made up in sets of four on fiber bases, one set being installed on each switchboard. Where the



AMMETER JACK FIG. 3.

Fig. 3.

line voltage does not fluctuate seriously, readings taken in this manner are nearly as reliable as simultaneous readings on separate meters. The device not only reduces the number of meters required, but largely eliminates difficulties due to differences in calibration where more than one instrument is used.

The accuracy of meters has long been a matter of much uncertainty. On account of the inconvenience of improvising apparatus for satisfactory calibration, instruments have often been kept in service long after their indications have become questionable. To remedy this difficulty and render possible frequent and systematic calibration, a table has been constructed carrying all the necessary apparatus. To the top

are fixed an alternating and a direct current voltmeter and an alternating and a direct current ammeter with a variable ratio current transformer and a set of shunts. Space is also provided for resting portable meters which it is desired to check. Control of voltage and current is accomplished through rheostats suspended underneath. The table legs run on rubber tired casters permitting the outfit to be readily moved to any switchboard panel in the laboratory. This equipment, it is believed, will do much to increase the reliability of experimental results.

A novel piece of apparatus has been devised to show that the rotor of an induction motor is affected by the polyphase primary exactly as it would be affected by a unidirectional field mechanically rotated. The device consists of an ordinary squirrel cage, two-phase induction motor so mounted that the primary can be rotated mechanically by belting to another motor. By introducing direct current through slip rings into one of the two-phase windings and rotating the frame a mechanically revolving field is produced. By fixing the frame and introducing two-phase current into the windings, the machine becomes a regular induction motor. Observations of torque developed in the secondary show the effects in each case to be identical, thus demonstrating that the polyphase winding actually produces a revolving field. Ball bearings between the frame and rotor greatly reduce the frictional torque making accurate measurements easy. By revolving the direct current field at very slow speeds with the rotor locked, the relation between torque and slip may be easily studied. This motor is expected to be of great assistance in bringing home the principles of induction motor operation.

For studying synchronizing and hunting of alternators, a very satisfactory stroboscope has been arranged as follows: The two alternators to be paralleled are set several feet apart with shafts in line. On the inside end of the first shaft is mounted a circular disk having a narrow radial slot near the edge. On the adjacent end of the other shaft is fixed a disk

or pulley bearing a white mark along the diameter. By observing this mark through the slot in the first disk, variations from the synchronous position are very clearly shown. The arrangement is much superior to the usual ones involving arc lights as the indications are very sharply defined.

The above special features of the Missouri University laboratories are here submitted with the hope that there may be found among them some suggestions or ideas that will prove to be of value in other institutions.

DISCUSSION ON "A QUIZ ON QUIZZES."

In response to your note at the end of Mr. W. H. Rayner's quiz on Quizzes in the October number of the BULLETIN of the Society for the Promotion of Engineering Education, I want to express my compliments on this paper. It seems to me that it sets forth the facts and comes to specific statements and conclusions which are admirable. In almost all of the answers given by Mr. Rayner I should agree, but it appears to me that he gives too small a credit to accuracy where he refers to the problem of grading.

DUGALD C. JACKSON.

In connection with the list of questions by Mr. Rayner, I submit the constantly recurring question: Q. Shall there be an exempt list? This question has recently occupied the attention of the members of this faculty and has been decided that the exempt list shall be optional with departments. Whether the following answer is the correct one or not I cannot say. A. From the standpoint of best teaching efficiency the exempt list method is all that is desirable, for it tends to make the class grade higher than would be otherwise possible. The students generally do better work on monthly tests in an endeavor to average high enough to be placed upon the list; apparently the employment of the exempt list is productive of good results.

I submit the following answers to the questions, without any idea that they are the correct answers, but simply as they appear to me.

PURPOSE.

Q. (*A*) For the student, what is the purpose of a quiz?

A. In the average lecture or other course the quiz gives the student opportunity to review the subject matter of the preceding lectures and thereby formulate a unified whole; further it enables him to demonstrate the proof of his knowledge of the subject, whatever it is.

Q. (*B*) For the teacher, what is the purpose of a quiz?

A. In reviewing the results of a quiz, the instructor may detect wherein the students are deficient, and broadly determine the quality of his teaching methods. Possibly more than one quiz would be necessary to determine the latter.

Criteria.

Q. Shall the questions be general or specific in nature?

A. A judicious mixture of both the above might well be included. I aver that the word "discuss" gives the student opportunity for expression of originality, if he has any, and further, expansion. Apparently the word "discuss" may and often does present loop-hole for escape to the student on the ground of misunderstanding.

Q. Are catch questions permissible?

A. Catch and so-called trick questions should not constitute the teaching methods of any fair minded individual and positively should be barred—being unfair as the student is necessarily laboring under a strain. The form in which the question is put will be of no substantial consequence as long as the meaning is perfectly patent.

Q. Shall all questions have the same weight?

A. Apparently no; the weight of the question should depend on the material embodied and the time necessary for completion.

Q. Shall the questions be limited to the subject matter covered since the last quiz?

A. In order to avoid confusion, it might be well in some subjects to so limit the questions, but no iron-clad rule should be laid down.

Q. How long should a quiz be?

A. This may vary very much, but ample time should be allowed for the completion thereof.

Methods.

Q. Shall the date of a quiz be announced?

A. Since the practice of "springing" tests on unlooked for

occasions keeps the student in a state of mental unrest, it would seem as though definite announcement, of say one week, would promote the best results.

Q. How shall the questions be presented to the students?

A. This is apparently of little moment.

Q. Shall the questions be given with or without the use of textbooks?

A. In some courses the use of texts, notes, and other sources of information would be impossible, as such use would defeat the prime utility of the quiz; in other courses the use of texts, notes, etc., is virtually necessary, and if such use is permitted the students should be apprised of that fact.

Q. Should papers be returned to the students?

A. Invariably yes; it is not apparent what object there would be in retaining them.

Q. What means shall be taken to assure the teacher that the student has profited by his mistakes in the quiz?

A. A complete review in the classroom of each quiz should he held in order to dispel any vagueness regarding the quiz, and further if there be wholesale failure on any of the questions, repetition in the next quiz would be in order.

GRADING.

Q. Should the personality of the student be a factor in fixing the grade?

A. Ethically no; the quiz is given for a definite purpose, to wit, the determination of the quality of the instruction and the knowledge of the student, so why any extraneous factor should influence the final grade is not apparent. There are recklessly flagrant cases where men have "passed" courses on their reputations acquired in another.

Q. In computations, what weights should be given to accuracy of results and method?

A. Method must be given due allowance, although in problem work where accuracy is generally more or less essential the weight of method must necessarily be limited.

Q. How shall the class average be taken into account?

A. Generally speaking, entire low class average indicates one or more of the following things: abnormally stupid class, absence in the curricula of proper prerequisites, or inefficient quality of instruction. Boosting of class averages should generally not be done except in extreme cases, although under some circumstances it is often the only resort.

Cribbing.

Q. Should the instructor remain in the room during a quiz?

A. While strictly at variance with the so-called honor system, I submit that on the whole there will be less tendency on the part of students (in the upper classes) to crib if the instructor is not in the room during the test. In the first and second year classes careful watching is virtually needful. A sort of voluntary honor system without the undesirable features of the strict system would seem to be generally desirable.

Q. What precautions are legitimate?

A. The students should be seated far enough apart so that the borrowing of aid is not immediately suggested by the sight of the paper of their neighbors, or, as suggested by Mr. Rayner, two sets of questions may be used if a suitable seating arrangement is impossible under stress of numbers.

Q. What disciplinary action should follow convictions for cribbing?

A. Although expulsion from the institution for variable lengths of time follows conviction for cribbing, generally, this would seem somewhat harsh except in repeatedly flagrant cases. The penalties levied will vary with the nature of the offence and with the personality of the offender and no definite rule can be laid down to cover the cribbing offences collectively. Reformation of the offender is requisite and sufficient.

R. J. B. Anderson.

ADDITIONAL NOTES.

President Jacoby has appointed President Hollis Godfrey, Drexel Institute, as the delegate and Dean F. A. Goetze, Columbia University, as the alternate to represent this society at the Second Pan American Scientific Congress to be held in Washington, D. C., December 27, 1915, to January 8, 1916.

The attention of the members of this Society who reside in or near New York City is called to monthly meetings of the New York Section of the American Institute of Mining Engineers. These meetings are held the first Wednesday after the first Tuesday of each month from October to May inclusive, at the Machinery Club, 50 Church Street, and are preceded by a dinner at 6:30.

An invitation has been extended by the National Bureau of Standards to the members of the Society to participate in the Exhibit of Graphic Methods to be held at the Hotel Raleigh, Washington, D. C., Monday, December 27, to Friday, December 31, inclusive, during the meetings of the national scientific societies and of the Pan American Congress. The interest which this Exhibit has already aroused assures its complete success.